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METR 100: Weather and Climate–Peer Review of Teaching Project Benchmark Portfolio

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Peer Review of Teaching Project
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Spring 2019

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ABSTRACT

The target course for this benchmark portfolio is METR 100: Weather and Climate, an introductory-level course about Earth's weather and climate. Students enrolled span all undergraduate class levels and during the spring semester most students are non-science majors. Through the Peer Review of Teaching Project, this course was re-designed to better align the course objectives with the University of Nebraska – Lincoln's Achievement Centered Education (ACE) program. The number of topics covered during the semester was reduced and time spent practicing skills was increased in an effort to improve student attainment of course goals.

This portfolio outlines course objectives, pedagogical approaches and describes course activities that were used to give students practice with the desired skills. It includes a discussion of the development and implementation of an assessment tool (pre-post-test) for evaluating student achievement of the learning goals. The results of the assessment suggest that decreasing the number of topics covered and increasing the amount of time spent working toward the learning goals had a positive effect on student achievement of the learning goals.

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INTRODUCTION

The Peer Review of Teaching Project (PRTP) is a year-long program that offers faculty members a supportive environment to discuss teaching and learning and provides a model for assessing and documenting instructional practices and student learning. The Benchmark Portfolio is used to document this analysis and reflection.

The main goal for this Benchmark Portfolio was to better align the METR 100: Weather and Climate course objectives with the University of Nebraska – Lincoln's Achievement Centered Education (ACE) program. Prior versions of the learning goals for the course were very specific to the content knowledge in the field and did not align with the University's ACE 4 Outcomes. This Benchmark Portfolio describes the course re-design and assessment of the learning goals for METR 100: Weather and Climate during the Spring 2019 semester. It outlines course objectives, pedagogical approaches and describes course activities that were used to give students practice with the desired skills. It includes a discussion of the development and implementation of an assessment tool for evaluating student achievement of the learning goals. It concludes with planned changes for the METR 100: Weather and Climate course in the future and a reflection on the Peer Review of Teaching Project.

Section 1. General Course Information

1.1 Course Description

The target course for this benchmark portfolio is METR 100: Weather and Climate (Spring 2019). This is an introductory-level course about Earth's weather and climate. Students learn about Earth's atmosphere, its variability in time and space, how weather systems develop and evolve, how weather gives rise to climate, and how Earth's climate varies spatially and temporally.

The students enrolled in METR 100 span all undergraduate class levels within the University. Most of the students in the course are non - science majors, and many of the students are first-year students. METR 100 is the first required major -specific course for Meteorology – Climatology program within the Department of Earth and Atmospheric Sciences at the University of Nebraska – Lincoln, but most majors take it during the Fall semester. Enrollment for the course is capped at 95 students and the course is at capacity every semester.

1.2 Role of Course within University and Department

Weather and Climate (METR 100) is a course in the University's Achievement Centered Education (ACE) Program. The ACE Program consists of 10 student learning outcomes and was designed to ensure that all graduates, regardless of major, are exposed to multiple disciplines and develop the knowledge and skills to be productive members of society. METR 100 is an ACE 4 course and seeks to teach students to, "Use scientific methods and knowledge to pose questions, frame hypotheses, interpret data, and evaluate whether conclusions about the natural and physical world are reasonable" (UNL 2019).

In addition, this course serves as the first major-specific course for students in the Meteorology – Climatology Program in the Department of Earth and Atmospheric Sciences, within the College or Arts and Sciences. It serves as a pre-requisite for the next major-specific course within the Meteorology – Climatology program, Introduction to Atmospheric Science (METR 205). The METR 205 course also serves as in introduction to many basics of meteorology and climatology, though the applications and activities within the course involve more advanced mathematics and problem solving than in METR 100. So, while it is important for Meteorology – Climatology majors enrolled in METR 100 to be exposed to the course topics outlined in an introductory atmospheric science textbook, it is most important that these students leave METR 100 with the ability to interpret atmospheric science data, and to evaluate and solve atmospheric science problems. In this sense, the program-related goals for the majors in the METR 100 course and the ACE 4 learning outcomes for the non-majors in the course are quite similar.

1.3 Course Objectives and Learning Goals

In deciding on the course objectives and learning goals, it is important to think about what knowledge and skills we want students to have after successfully completing the course. While Meteorology – Climatology majors will eventually need to retain many of the foundational concepts of meteorology and climatology, it is not realistic to expect them, or non-majors, to retain every bit of content presented in an introductory textbook. In addition, introductory textbooks often contain more content than can reasonably be addressed in a single semester. Therefore, my goal is for the students to leave this course with a general understanding of Earth's atmosphere and climate. More importantly though, I want them to be able to think critically and analyze scientific information with which they are presented. They should be able to ask questions and investigate a topic to determine if what they have been shown, or what they have read, is reasonable. The ability to critically analyze information presented to them, and to evaluate whether conclusions are reasonable are skills that can be applied in future college courses, and after college.

For this course I defined three broad course objectives that are strongly tied to the Atmospheric Science and Climate Science Literacy Principles (UCAR 2007). The three course objectives that I will aim for the students to leave the class with and retain after they have forgotten many of the finer course details are:

1. The understanding that Earth's atmosphere varies in both time and space, giving rise to weather and climate, and humans can not only affect Earth's atmosphere and climate, but they depend on it.

2. An understanding of how scientific observations are made, and that they are used to improve our understanding of weather and climate.

3. The knowledge, skills and tools that will allow them to become well-informed, productive members of society (scientific literacy).

Using these broad course objectives as a framework for developing the course, I defined three learning goals for students to achieve by the end of the course. These are adapted from the ACE 4 learning outcome set forth by the University of Nebraska – Lincoln (UNL 2019). My goal is to guide students through the course topics in a way that helps them develop:

1) An understanding of basic atmospheric properties and processes.

2) The ability to:
    a. interpret weather and climate data,
    b. investigate questions they have about the data, and
    c. to make predictions using that data and determine uncertainties.

3) An appreciation for the complexity of the weather and the climate system, and to apply course concepts to their own observations of the natural world.

The course objectives and student learning goals served as the framework for the course structure. They were used to guide the development of course activities and assessments, as well as the instructional strategies used during the semester. These course objectives and learning goals were shared with the students to inform them of my expectations from the start of the course and to serve as a guide for their learning. If met, the objectives and goals will prepare the students for success in future courses and the knowledge, skills and tools they learn will allow them to become well-informed, productive members of society, regardless of their major.

Section 2. Course Materials, Activities and Teaching Methods

2.1 Course Materials

All of the course materials were available to the students through Top Hat, a learning technology platform (https://tophat.com/). Course materials included a course textbook and associated reading assignments, class notes (annotated PowerPoints), and instructor created in-class and laboratory activities. Occasionally, weather maps and diagrams were printed and supplied to the students for hand analysis.

The textbook, Weather & Climate: Introductory Principles & Exercises by Marius Paulikas (https://tophat.com/marketplace/science-&-math/earth-sciences/textbooks/weather-&-climate-introductory-principles-&-exercises-marius-paulikas/1958), was completely customizable so homework assignments consisted of embedded reading questions that were a combination of instructor created questions and those provided by the textbook. Students were expected to complete reading assignments outside of class, before each class period. The reading questions were dispersed throughout the reading assignment to encourage students to pause after reading some of the material and test their understanding. When answering a reading question, students were able to see whether or not their submitted answer was correct. If incorrect, a hint was provided and they were able to answer the question again. Students were allowed unlimited attempts at the reading questions before the due date. The goal of this method was to allow students to actively process the information while they were reading, and to provide a low – stakes opportunity to practice the course learning objectives.

Course notes were provided in real-time to the students using PowerPoint presentations presented in the Top Hat platform. The course notes were available to students (via Top Hat) immediately after class. The course notes generally included a list of anticipated course topics and learning goals for the day, and because I could track student progress on the reading assignments, I was able to tailor PowerPoint lessons to address the more difficult topics and skills. The course notes also included definitions, visuals (e.g., pictures, videos, real-time weather data), and embedded questions to assess student comprehension and skills during the class period.

The lab activities were instructor designed with the learning goals in mind. They were administered through Top Hat during a lab session taught by teaching assistants. The lab activities were assessed and graded by the teaching assistants, with instructor guidance. Since I did not have direct contact hours with the students during the laboratory sessions, the lab activities were not assessed for this portfolio. Appendix A includes a copy of the course syllabus which outlines this information in more detail.

2.2 Teaching Methods and Activities

My approach to teaching in this course was a balance between teacher-centered (i.e., students are passive learners and lecture is the dominant teaching method), and student-centered (i.e., teacher is the facilitator of student-driven inquiry and lecture is minimal or absent entirely). The reason that I have not chosen a purely student-centered approach is that the size of the course (approximately 95 students), limits my ability to develop and assess the large number of in-class activities that would be necessary to facilitate student learning using this method. I avoid lecturing for the entire period because I want to ensure that students are given opportunities during the class period to ask questions, build knowledge and apply course concepts, which has been shown to promote deeper learning.

A typical class period began with time for students to ask questions about the reading assignment and reading questions. If students did not pose questions, then my PowerPoint was prepared with questions for them, based on my assessment of their reading assignment scores. Peer instruction is an evidence-based, interactive teaching method that consists of questions or problems interspersed with lecture material (Crouch & Mazur 2001). Students are first asked to think about and respond to a question individually using a classroom response system (e.g., Top Hat). If most students correctly answer the question, a quick explanation of the correct response is provided and we move on. If the individual responses indicate that a many of the students are still struggling, then I will instruct the students to share their answers with each other and explain why they chose that answer as the correct one. After a short discussion period, students answer the question again as individuals. Typically, the class will, through group discussions facilitated by the instructor, reach a consensus on the correct answer. The goal of using peer instruction is to increase student engagement and to allow me to assess their understanding of the topic being presented. In addition, peer instruction offers the student a means to gauge their understanding of the material.

Occasionally (approximately every other week), part of the class period was spent working on an activity that allowed students to apply the concepts and skills they recently learned, and to provide me with time to work with students in smaller groups. Students were provided with a quick review of the topics and skills necessary to complete the activity and then they were given class time to work together on the activity. Following the short work period, we would reconvene and discuss the activity as a larger group. The activities were not typically collected for assessment or grading.

Appendix B includes an example of an in-class activity that was designed to give students an opportunity to practice learning outcomes #1 and #2 (a-c). The class period began with a review of the forces involved in atmospheric motion at the surface and upper levels of the atmosphere. Then students were provided with maps of the surface and an upper level in the atmosphere. Students were given time to work individually and then in groups to complete the problems presented. The problems required students to use their existing knowledge of forces to analyze the data presented and predict the wind direction at each level. Near the end of the class period, we reconvened as a larger group to compare their findings to the observed wind directions and discuss any questions they had developed during the activity.

While peer instruction questions help me to assess the understanding of the class as a whole, I am not able to address the questions and concerns of the students that are struggling the most. Even after group discussion and a second chance at the question, there are inevitably some students that still get the incorrect answer. Unfortunately these students are generally least likely to ask follow-up questions and begin to fall behind the rest of the class academically. Including occasional in-class activities that are completed in small groups gives these students (as well as the rest of the class) a chance to ask questions about the topic or skill in a less threatening environment (small group or one-on-one with the instructor or a peer). I also make it a point during these sessions to talk with students that might appear to be struggling. Peer instruction and in-class activities pair well with traditional lecture to expose students to new content and skills, while also giving them time to process the material and apply new skills. Both teaching methods allow me to assess the students during class and adjust my lesson plan according to their learning needs.

Short quizzes were administered after 3-5 class periods. Quizzes were completed as individuals and reviewed the following class period. When quiz questions were found to have very low scores and indicate that students were struggling with a particular concept or skill, additional opportunities to practice the skills were provided. These opportunities were presented as group activities or group quizzes and after a period of work time in small groups, we discussed the problems and their solutions as a whole class. These sessions provided additional opportunities to practice the skills associated with the course learning goals.

Toward the middle of the semester, a final project is assigned (see Final Project Instructions in Appendix A). This final project serves as a means to assess how well the course addresses the learning goals (and the ACE 4 learning outcomes). This is a group project that requires students to develop questions they have about a weather or climate phenomenon, or a particular weather or climate event. The groups are expected to prepare an oral presentation to communicate their findings to the class. Each student is also required to compile an individual written summary of their results. They are provided with at least two in-class periods to work together in their groups on the project plan and to develop the oral presentation, but the written summary is expected to be completed individually and outside of class time. The work periods provide students in-class time to work together and collaborate on the project, but it also provides them with time to solicit feedback from me on their progress, and to ask questions on gathering and analyzing data, and about the expectations for the project. Using information gleaned from my interactions with each group, I am able to address the whole class to clarify expectations and address the learning goals as needed.

2.3 Course Design and the Broader Curriculum

The instructional methods described in the previous section are how I approach all of my courses, regardless of the course topic and its place in the broader curriculum. Since this course is required for Meteorology-Climatology majors, I made sure to incorporate the foundational knowledge and basic scientific process skills for those students to be successful in subsequent courses. But basic scientific literacy is important for all university majors. As such, this course serves the general education curriculum as an ACE 4 course. The course was designed in a way that it not only prepares Meteorology-Climatology majors for their subsequent courses, but also gives non-majors exposure to the process of scientific inquiry and analysis, and helps them develop basic skills to understand and appreciate the complexity of Earth's atmosphere and climate.

Section 3. Analysis of Student Learning

3.1 Methodology

3.1.1 Development of the assessment (pre-post-test)

To allow students adequate time to interpret and apply course concepts, the amount of content covered in a typical introductory course was reduced. The goal of the course redesign was to allow students ample time to not only increase their knowledge of atmospheric science concepts, but also their ability to solve atmospheric science problems and understand the scientific process. Because METR 100 is an ACE 4 course, these course objectives were strategically designed to align with the University's ACE 4 Outcomes. Therefore my goal was to guide students through the course topics in a way that helps them develop:

1) An understanding of basic atmospheric properties and processes.

2) The ability to:
    a. interpret weather and climate data,
    b. investigate questions they have about the data, and
    c. to make predictions using that data and determine uncertainties.

3) An appreciation for the complexity of the weather and the climate system, and to apply course concepts to their own observations of the natural world.

The University's ACE 4 Rubric (see Final Project Instructions in Appendix A), and the Atmospheric Science Literacy Principles document (UCAR 2007) were used to create a pre-post-test for assessing achievement of the learning goals. The assessment was designed to evaluate students' skills in the areas shown in Figure 1. Notice the overlap between the course learning goals and the ACE 4 Learning Outcomes.

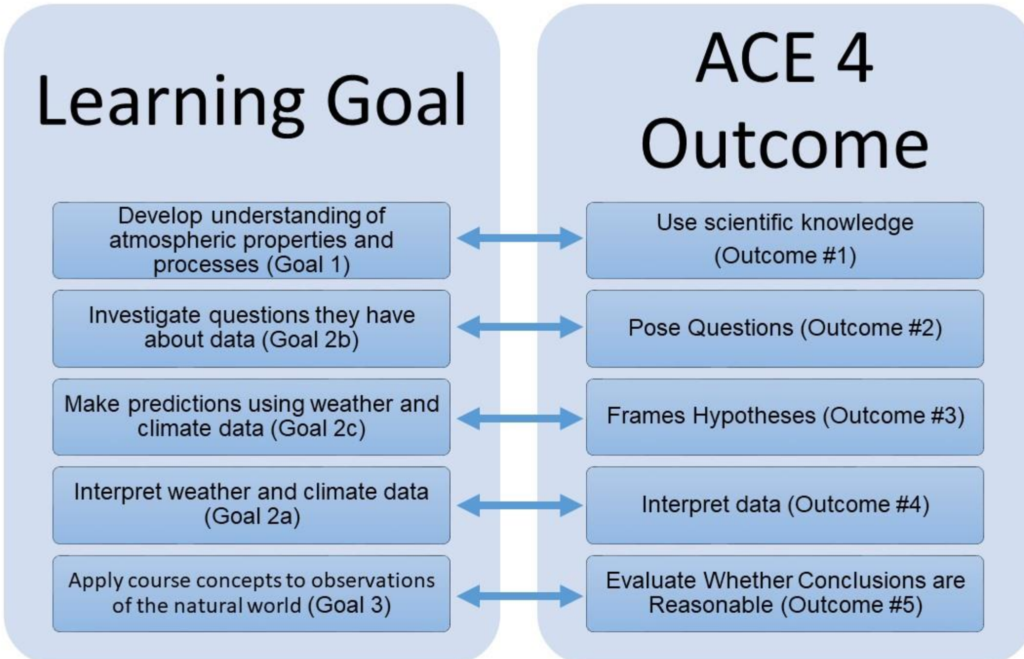

Figure 1. Illustration of how course learning goals are mapped to the University's ACE 4 Outcomes.

3.1.2 Validity and Reliability of Pre-Post-Test

The assessment consists of 31 dichotomously scored (i.e., right or wrong) multiple choice questions on atmospheric science content and applications. The assessment tool was vetted by an independent panel of three experts in the field to assess the grammar, formatting, accuracy and clarity of each question. The panel was also used to ensure that the content and skill categories assigned by the authors were appropriate (i.e., that the individual questions match their objectives. Through this process, it was determined that the assessment contains the following number of questions in each category: Use Scientific Knowledge (9), Poses Questions (5), Makes Predictions (4), Interprets Data (8), and Evaluates Conclusions (5). The goal of this project was to determine if reducing the number of topics covered in the course and increasing the amount of time spent working toward the learning goals had an effect on student achievement of the learning goals. Since the course learning goals are skill-based, the content categories will not be analyzed in this portfolio. In addition to the questions on course content and skill, the assessment also included a demographics section that asked students to: identify their major(s), list any previous or concurrent science coursework, and their interest in various weather and climate topics.

With the content validity check complete, the pre-post-test instrument was field-tested during the Fall 2018 (METR 140) and Spring 2019 (METR 100) semesters to assess its reliability (N = 144). The results from the field-testing were used to ensure the individual questions on the assessment were internally consistent (i.e., Are the test questions measuring what they are designed to assess?) and reliable (i.e., Do the test scores represent true differences or did the differences occur by chance?; Engelhardt 2009).

There are a number of statistical analyses that can be done to assess the internal consistency and reliability of a test. Four important statistics to consider are the difficulty of the test items, the discrimination index (measures how well the test items distinguish between students that know the answer and those that don't), Ferguson's Delta (examines discriminatory power of the test as a whole), and the Kuder-Richardson 20 (KR-20) value (examines internal consistency of the test as a whole; Engelhardt 2009).

The difficulty of the individual test items was determined by dividing the number of students answering a test item correctly, by the total number of students taking the test. The difficulty index ranges from 0 to 1, with a 0 indicating no students answered correctly (i.e., a difficult question) and a value of 1 indicating that all students answered correctly (i.e., an easy question). The difficulty index for a test question is ideally equal to 0.5, but values from 0.3 to 0.9 are considered acceptable. The difficulty index for the pre-post-test questions ranged from 0.11 to 0.7431, with an average difficulty of 0.4724. Twenty-seven of the pre-post-test questions had an acceptable difficulty rating.

The discrimination index is calculated to determine how well each test question distinguishes between high-scoring and low-scoring students. The discrimination index varies between -1 and 1, with an acceptable discrimination index being greater than 0.3. The index is strongly influenced by the difficulty of the question. All but one of the pre-post-test questions were determined to be excellent discriminators, with the outlier still rated as a good discriminator.

Ferguson's Delta is a statistical measure that describes how well the test as a whole discriminates between students. The value varies between 0 and 1, with a value greater than 0.9 considered acceptable. The Ferguson's Delta value for the pre-post-test was 0.9801 indicating that the pre-post-test as a whole does a good job of differentiating between students.

The Kuder-Richardson 20 (KR-20) statistic looks at the covariance of the test questions and can be used as a measure of internal consistency of the entire multiple choice test (used for tests with dichotomously scored items only). A KR-20 value above 0.7 indicates a test is statistically consistent. The KR-20 value for the pre-post-test was 0.8339 indicating that the items on the pre-post-test do a good job measuring what they were designed to measure (i.e., the Interpret Data questions provide a good measure of the students' ability to interpret data).

Additional student populations (e.g., different institution types and geographic locations) are needed to increase the robustness of the results described here, but the initial validity, consistency and reliability statistics are promising and suggest that the attainment of the learning objectives by the Spring 2019 METR 100 students can be assessed using the pre-post-test results.

3.2 Demographics of study population

To assess how well the learning objectives were met, the assessment was given as a pre-test early in the Spring 2019 semester. Ideally, the pre-test would be given before the students were exposed to any of the course content, but there were aspects of the course plan that could not be altered for this project, and the pre-test was administered after the first unit of the course (during the 5th class). Student exposure to the initial course content will be taken into account when comparing the pre-test to the post-test scores. The post-test was given on the second to last day of class after all of the semester material was presented. The final class was an in-class work day for the final group project. While the skills and concepts from the semester were used during this class period, no new concepts or skills were introduced. The analysis of the pre-post-test will be used to assess whether students exhibited any learning gains. In addition, the analysis of student performance will include an investigation into whether or not relationships exist between various demographics and performance in the course (e.g., was there an increase in student performance based on current/previous science coursework, participation in course activities, etc.). Students were also asked to rate their level of confidence in their choice after answering each question.

Of the 96 students in the course, 55 students completed the pre-test and post-test and consented to allow their data to be used in this study. The study group was comprised of 19 first-year students (34.5%), 17 sophomores (30.9%), 10 juniors (18.2%) and 9 seniors (16.4%). This included 21 females (38.3%) and 34 males (61.8%). Figure 2 displays the ages of the participants. The majority of students (34) were between 19 and 20 years old. Figure 3 shows the variety of majors being pursued by the study participants. A large number of students taking the pre-post-test were majoring in Education (13), the majority of which were specializing in Elementary Education. Other popular majors were Business (6) and Engineering (5), with the Other category including a relatively large number of Computer Science (6) and Political Science (5) majors.

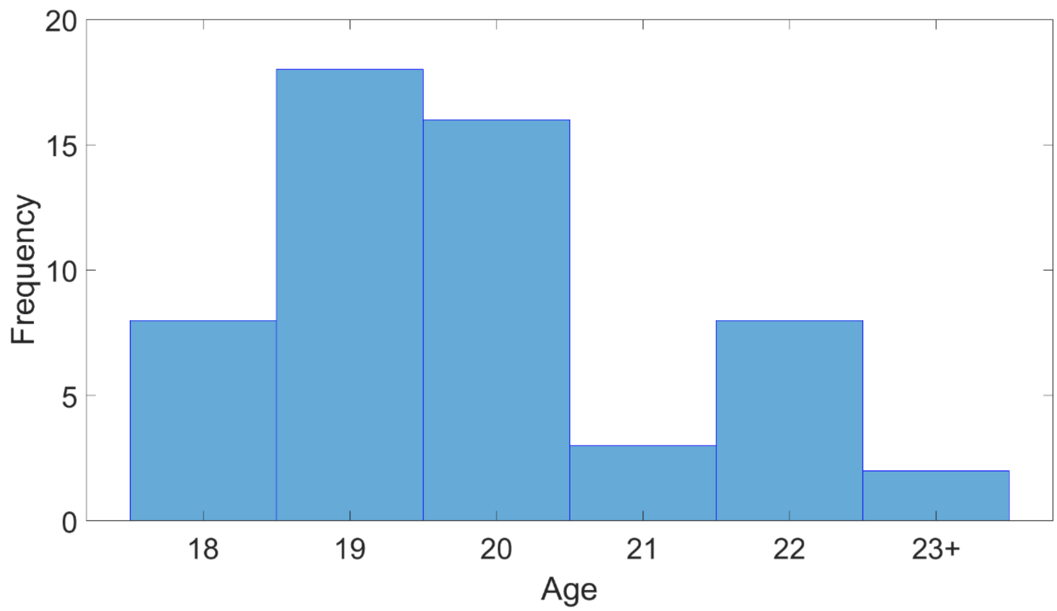

Figure 2. Age of students in study population.

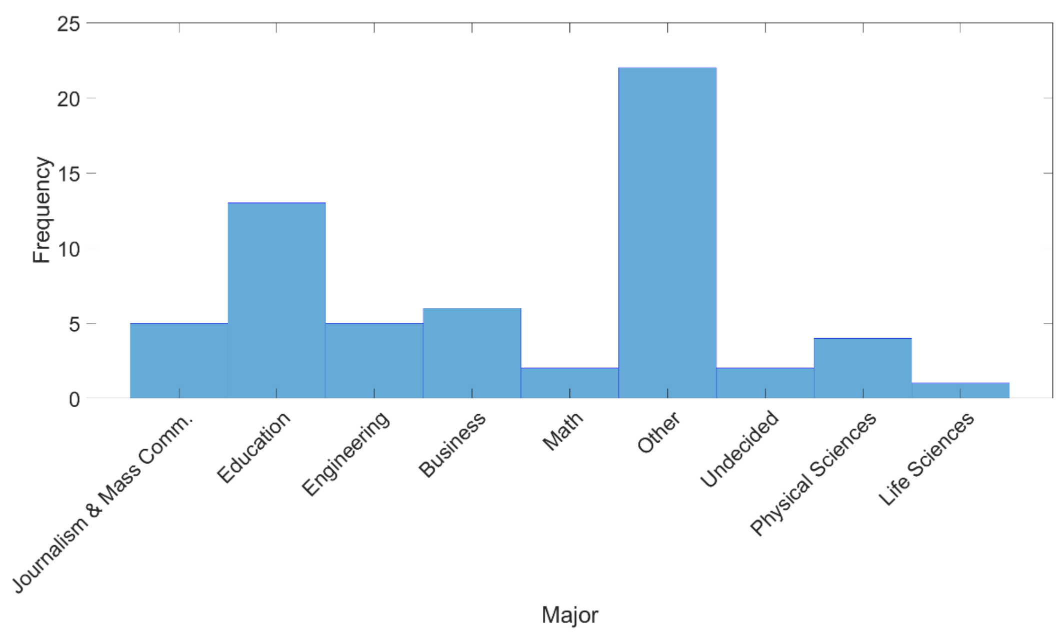

Figure 3. Majors of students in study sample.

Of the 55 students in the study, 36 (65.5%) had taken a science course prior to METR 100 in Spring 2019. Eight (14.5%) were taking another science course concurrently, one of which was taking another meteorology course.

3.3 Analysis of Student Learning

Table 1 provides summary statistics for the students in the Spring 2019 student population. Both the mean and the median test score increased by approximately five points between the pre-test and post-test, suggesting there were learning gains. We can be fairly confident in the mean scores and learning gains as the standard error of the mean is close to zero. However, the average post-test score was 13.84 out of 31, indicating the average percentage of correct responses on the post-test was just under 45%. Clearly there were still topics and skills that some students did not fully comprehend. Some of this may also be attributed to the four questions on the pre-post-test that had difficulty indices below 0.3.

Statistic	Pre-test	Post-test	Difference
Mean	8.91	13.84	4.93
Median	9	14	5
Standard Deviation	5.3	6.51	1.21
Standard Error of the Mean	0.07	0.08	0.01
Range of scores	23	28	5

Table 1. Summary statistics of the pre-post-test scores for the Spring 2019 semester.

Figure 4 shows the distribution of scores for the pre-test (red) and post-test (blue). The distribution of scores for the pre-test has a slight positive skew, indicating that the test was difficult. This may be a result of the four questions that had very low difficulty indices (difficulty index < 0.2), and is something to consider revising for future versions of the pre-post-test. From the figure, we can also see that while there was a shift toward higher scores overall, there is still a handful of students that scored less than five (out of 31) on the post-test, indicating that not all student scores improved. This larger spread in student scores is evident in the increase in the standard deviation and range of scores between the pre-test and post-test.

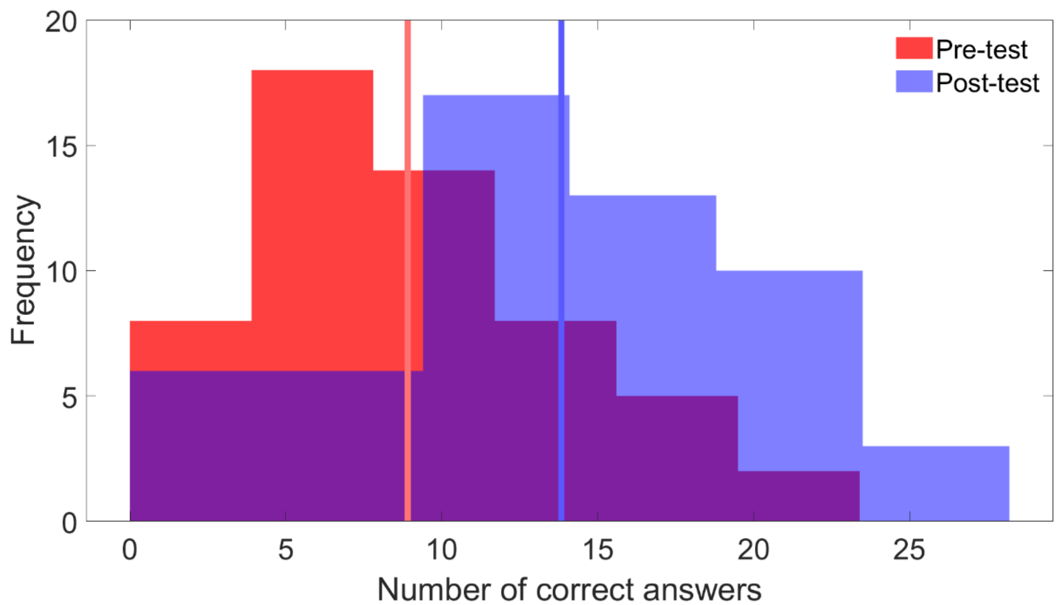

Figure 4. Distribution of student scores on the pre-test (red) and post-test (blue). Vertical line represents the mean score for the pre-test (red) and post-test (blue). Total correctness score is out of 31 questions.

While general learning gains were a goal of the course, as they would be in any course, the main goal of this project and the course redesign was to determine whether decreasing the number of topics in the course while increasing time spent working on skill development, would help students achieve the learning objectives. After all, the goal of an ACE 4 course is to prepare the students for success in future courses by helping them build the knowledge, skills and tools they will need to become well-informed, productive members of society, regardless of their major.

The top left panel of Figure 5 shows the change in the total number of correct answers from the pre-test to the post-test for each of the 31 questions. This was computed by subtracting the total number of correct responses (out of 55) on the pre-test from the total number of correct responses on the post-test. A positive value indicates that more students answered a question correctly on the post-test. The change in the mean confidence rating between the pre-test and the post-test was also computed for each question. The remaining five panels show the change in the total number of correct answers and the change in the mean confidence for each skill category (from the pre-test to the post-test).

A visual analysis of Figure 5 shows us that there were five questions that exhibited a decrease in score from the pre-test to the post-test, two of which also showed a decrease in confidence (two left quadrants in All Questions panel). This includes one Uses Scientific Knowledge question, three Interpret Data questions, and one Evaluate Conclusions question. Table 2 shows the difficulty index and discrimination index for these questions, and the acceptable values for each index (Engelhardt 2009). We can see from Table 2 that the third Interpret Data question (Q12) and the Evaluate Conclusions question (Q10) have difficulty ratings and discrimination indices below the acceptable threshold, indicating that these questions were likely too difficult and therefore they did not do a good job discriminating between high-scoring and low-scoring students. These questions will likely need revision before the next distribution, or should be removed from the assessment completely.

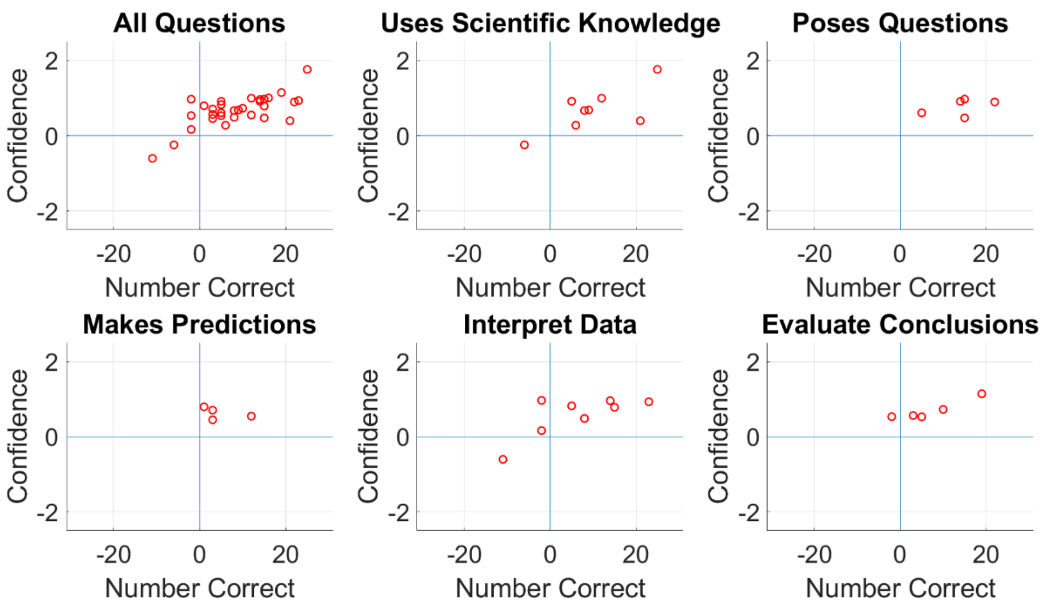

Figure 5. Change in total number of correct answers for each of the 31 questions and change in mean confidence from the pre-test to the post-test. Top left panel shows changes for all skill categories, with remaining panels displaying data for each skill category.

Question Number	Question Type	Difficulty Index	Discrimination Index
1	Interpret Data	0.47	0.52
2	Interpret Data	0.58	0.52
4	Scientific Knowledge	0.60	0.45
10	Evaluates Conclusions	**0.16**	**-0.06**
12	Interpret Data	**0.04**	**0.13**

Table 2. Question numbers with decrease in total correctness score between pre-test and post-test. Question type, difficulty index and discrimination index are shown for each question.

Questions 1, 2 and 4 exhibited a decrease in the total number of correct answers and confidence between the pre-test and post-test but these questions have desirable difficulty and discrimination ratings so the decrease in total correct answers and confidence between the pre-test and post-test should be investigated more thoroughly (see APPENDIX C for these questions). Questions 1 and 2 were designed to test the students' data interpretation skills. The decrease in the total number of correct answers for Question 2 is likely a result of the delay in the pre-test distribution. The course content and skills needed to solve this problem were taught and practiced during the first four classes and thus the students had just recently practiced problems very similar to this test question. By the time that the post-test was taken this skill was only intermittently used in the course, and had not been used in a couple of weeks. This is also the question with the biggest decrease in confidence. Since students were instructed not to study for this test, and several weeks had passed since students were asked to utilize this skill, they were no longer confident in their ability to answer the question correctly. The same assumption can be made about Question 4. In retrospect, the figure provided for Question 1 is very detailed and contains a lot of information that is unnecessary for solving the problem, and the resolution was a bit low. It is possible that replacing the figure for this problem to remove irrelevant information and increase the resolution of the image would increase the likelihood that students would successfully answer this question in future studies.

Despite the issues with the five questions discussed above, the assessment tool did prove to be useful in evaluating student learning in each skill category. To determine if the increases in the student scores for each category were statistically significant, a paired sample t-test was used to examine the pairwise difference in student scores between the pre-test and post-test. The paired sample t-test aims to determine if the increase in student scores can be attributed to the instructional methods and learning activities, or if they simply occurred by chance.

Table 3 shows the mean difference in scores between the pre-test and post-test for each skill category. The table also lists the p-value for the 99% confidence interval. From the table we can see that except for the Makes Predictions skill category, the learning gains observed from the pre-test to the post-test are statistically significant at p = 0.01. That is, there is only a 1% chance that the increase in student scores occurred by chance (excluding the Makes Predictions questions).

Although the mean difference for the Makes Predictions section was not statistically significant at p = 0.01, it was statistically significant at p = 0.1. There were only four questions classified with this skill type, and two of the questions have a low difficulty index, indicating the questions may have been too difficult and should possibly be revised before the assessment is used again. In addition, it would be best to develop more questions for this category before drawing conclusions about the student data.

Skill Type	Mean Difference	p-value
Scientific Knowledge	1.45	6.03E-06
Poses Questions	1.29	2.69E-07
Makes Predictions	0.35	**0.055**
Interprets Data	0.91	5.70E-03
Evaluates Conclusions	0.64	5.40E-04

Table 3. Mean difference in student scores between pre-test and post-test and p-values for each skill category (significant at p = 0.01).

3.4 Analysis of Participation and Student Achievement

The final analysis of student performance included an investigation into whether or not relationships exist between the various demographic data collected and performance on the pre-post-test and in the course (e.g., was there an increase in student performance based on current/previous science coursework, participation in course activities, etc.). While no statistically significant relationships were found between student scores and demographics such as age, sex, major or previous/concurrent coursework, participation does appear to be linked to student achievement. This relationship is visualized in Figure 6 which plots each student's participation score against their final course grade. The blue line is a line of best fit using least squares linear regression. The correlation coefficient indicates a strong positive correlation between participation score and final course grade with $r^2 = 0.91$. The p-value of $3.71 \; x \; 10^{-22}$ at the p = 0.01 significance level means that the probability of obtaining such a high correlation coefficient by chance will occur less than once for every 100 students. Therefore, a student's level of participation is highly correlated with their final course grade.

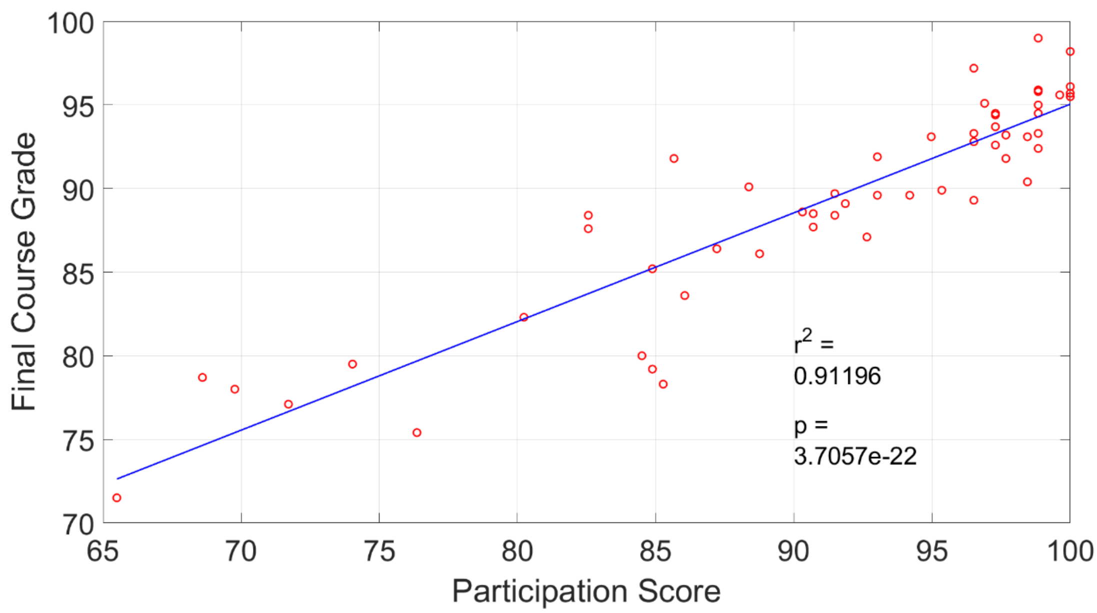

Figure 6. Correlation between participation scores and final course grades.

Section 4: Summary and Planned Changes

4.1 Summary and Planned Changes for Future METR 100 Courses

The data analysis presented here produced two main findings. First, evidence of the internal consistency, validity and reliability of a newly developed pre-post-test to be used for the analysis of science process skills. Room for improvement to the assessment was also identified. Second, through the analysis of student performance on the pre-post-test and in the course, I was able to determine that reducing the amount of content covered in a semester-long introductory atmospheric science course in order to focus more time on skill development resulted in statistically significant learning gains in all but one of the skill categories. These results indicate that the learning goals set forth at the beginning of the semester were met by a large majority of the students in the sample population.

As a result of these findings, I plan to make several changes to METR 100 for future semesters. First, I would like to make improvements to the assessment tool, which includes revisions to and removal of several of the test questions. I would also like to develop additional questions for the Make Predictions section of the test given that the test contains only four questions in this skill category and two of those questions have been identified as too difficult. Second, while the learning gains in the Interpret Data and Evaluates Conclusions skill categories were statistically significant, not all questions displayed an increase in correctness between the pre-test and the post-test, so there is still room for improvement to the instructional practices and the course design. In addition, overall post-test scores were low indicating that there are gaps that exist in student understanding of course topics and their ability to apply these concepts to new situations. Therefore, I would like to develop more in-class activities to target the Interpret Data and Evaluates Conclusions skills in particular, while also making sure to disperse them evenly throughout the semester to ensure that students have ample time to develop and practice these skills.

4.2 Assessment of the Portfolio Process

I enjoyed participating in conversations about teaching and learning with other UNL faculty through the Peer Review of Teaching Project. I walked away from these conversations with new ideas for classroom activities and ways to better facilitate student learning in my own classroom. In addition, the development of this Benchmark Portfolio has allowed me to assess and document how my instructional practices and course design affect student learning. I have been able to identify several areas where my instructional strategies and course design promote student learning gains, but this project also helped me detect areas where I can better support my students in developing their skills and attaining the course objectives. Writing this Benchmark Portfolio has been an informative and rewarding experience, and I look forward to using my findings to improve this course in future semesters to better facilitate student learning and attainment of the learning goals of this course and the University.

REFERENCES

Crouch, Catherine H., and Eric Mazur, 2001: Peer Instruction: Ten years of experience and results, *American Journal of Physics*, **69**, 970-977, https://doi.org/10.1119/1.1374249.

Engelhardt, Paula V., 2009: An introduction to classical test theory as applied to conceptual multiple-choice tests. *Getting Started in Physics Education Research* (PER), **2**, 1.

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University of Nebraska – Lincoln (UNL), 2019: Achievement – Centered Education (ACE), Accessed 30 May 2019, https://ace.unl.edu/.

APPENDIX A – Course Syllabus

Class Meetings*: TR 12:30 PM – 1:45 PM in 105 Teachers College Hall (city campus)

*You should also be enrolled in one of the four METR 100 lab sections (151 – 154).

Instructor: Dawn Kopacz (dawn.kopacz@unl.edu) **Office:** Bessey Hall 220C

Office Hours: Tuesdays and Thursdays from 2pm – 3pm**

**Please note that I will always be available in my office during my scheduled office hours (unless otherwise noted). You are also welcome to drop by my office with questions or concerns outside of these times as well, or make an appointment.

Teaching Assistants:

Haeli Leighty	Email: haeli.leighty@huskers.unl.edu
Erik Green	Email: egreen12@unl.edu
Kun-Yuan Lee	Email: klee12@unl.edu

Required Materials: Weather & Climate: Introductory Principles & Exercises
By Marius Paulikas from the Top Hat Marketplace: https://tophat.com/marketplace/science-&-math/earth-sciences/textbooks/weather-&-climate-introductory-principles-&-exercises-marius-paulikas/1958/70486 Please see Course Website below for more information about Top Hat.

> **Supplementary:** The following text is meant to be a supplement only. There are no assigned readings from this textbook. You might use it if you are struggling with a topic and want additional explanations or examples.
>
> Practical Meteorology: An Algebra-based Survey of Atmospheric Science by R.B. Stull. This text is available online for FREE at this link: https://www.eoas.ubc.ca/books/Practical_Meteorology/.

Course Content:
Physical behavior of the atmosphere; elements of weather and climate and their distribution over the earth. Weather map analysis and forecasting. Atmospheric circulation, precipitation processes, severe weather, air pollution, and the use of weather radar. Concepts of weather forecasting. You should also be enrolled in one of the four METR 100 lab sections (151 – 154).

Pre-requisites: MATH 101 or higher; or a qualifying Math Placement Exam score for MATH 102 or 104 or higher

Course Goals:

METR 100 is an ACE-4 class, which means the course seeks to fulfill the following student learning outcomes:

"Use scientific methods and knowledge to pose questions, frame hypotheses, interpret data, and evaluate whether conclusions about the natural and physical world are reasonable." You can read more about the ACE 4 learning outcomes here: https://ace.unl.edu/ACE%204%20Rubric%20Revised%204-27-16.pdf

My job will be to guide you through the course topics in a way that helps you to develop the following:

1) An understanding of basic atmospheric properties and processes.

2) The ability to:
    a. interpret weather and climate data,
    b. make predictions using that data,
    c. determine uncertainties in that data

3) Develop an appreciation for the complexity of the weather and the climate system, and to apply course concepts to your own observations of the natural world.

The lab session associated with this course will provide you with weekly opportunities to develop these skills. In addition, the in-class activities and homework/reading assignments will give you a chance to practice the skills. Your progress in developing the ACE 4 outcomes will be assessed through a final project (see Final Project Instructions).

Course Website: We will be using Top Hat (www.tophat.com) in class. You will be able to submit answers to in-class discussion questions, complete homework/reading assignments and review activities using Top Hat. We will also use Top Hat for quizzes and exams. Top Hat can be accessed using Apple or Android smartphones and tablets, desktop computers, laptops, and/or through text message.

You can visit the Top Hat Overview (https://success.tophat.com/s/article/Student-Top-Hat-Overview-and-Getting-Started-Guide) within the Top Hat Success Center which outlines how you will register for a Top Hat account, as well as providing a brief overview to get you up and running on the system.

An email invitation will be sent to you, but if you don't receive this email, you can register by simply visiting **our course website**: https://app.tophat.com/e/712213 **Our Course Join Code is 712213.**

Top Hat will require a paid subscription, and a full breakdown of all subscription options available can be found here: www.tophat.com/pricing.

Should you require assistance with Top Hat at any time, due to the fact that they require specific user information to troubleshoot these issues, please contact their Support Team directly by way of email (support@tophat.com), the in app support button, or by calling 1-888-663-5491.

Course Policies:

Environment: I expect the class environment to be interactive, professional, and challenging. Students are expected to arrive on time. Since Top Hat will require you to have a laptop or cell phone during class, it is obviously okay to have these items out during class. However, you must turn your phone/laptop to silent at the beginning of each class. This will minimize distractions for me and the rest of the class. This all being said, I hope we can have a fun semester learning together about weather and climate!

Late Policy: Your work should be turned in by the due date. No late assignments will be accepted. I will be understanding of emergencies that may come up, but in all cases, please communicate with me. If possible, please let me know prior to class via email or in person if you are unable to complete an assignment on time—we may be able to make other arrangements.

Class notes: Class notes will be available for you to view on your device during class using Top Hat. They will then be set to review in Top Hat after class.

Help with the Course: As your instructor, I want to see you do well in this course. I expect that you will have questions. Please interrupt me whenever something is unclear. If you have any questions about the material, homework, etc., you can also see me before or after class, send me an email, or come to my office hours. *I expect you to take an active role in making sure you understand the course material!*

Grades: The material covered on quizzes will come from your reading assignments, lecture material covered in class, and in-class activities. Some topics discussed in class will not be in the text and some topics covered in the text will not be covered in class. You are responsible for knowing and understanding all of this material. If you have questions about any of the material, please ask!

You will be able to view your answers to activities, reading assignment questions, etc. in Top Hat, but <u>your course grades will be computed and updated on Canvas throughout the semester.</u> The traditional A – F grading system will be used:

Percentage	**Letter Grade**
93-100%	A
90-92.9%	A-
87-89.9%	B+
83-86.9%	B
80-82.9%	B-
77-79.9%	C+
73-76.9%	C
70-72.9%	C-
67-69.9%	D+
63-66.9%	D
60-62.9%	D-
below 60%	F

Grades will be determined by the following schedule:

Reading questions	20%	
Quizzes (approx. 10)	20%	
In-class participation	20%	
Final project	20%	
	Date:	**Friday, May 3rd**
	Time:	**10am-12pm**
	Location:	**TEAC 105**
Laboratory*	20%	*see below

READING QUESTIONS (20%): You will be assigned reading from the textbook at the end of each class period. Embedded within the reading assignment will be several questions/problems. You are expected to complete these questions before the beginning of the next class period, revisiting any questions that were unclear before the next class. Each reading assignment will remain open for one week, at which point the answers the assignment will be set to review. This means that you will be able to view the correct answers for the reading questions, but you will no longer be able to answer them.

You will be graded for correctness. You are encouraged to work with your classmates to answer these questions, but each student must submit their own assignment in their own words. I am happy to answer questions related to homework problems, just ask! You will have unlimited attempts to correctly answer these questions. NO LATE ASSIGNMENTS WILL BE ACCEPTED.

QUIZZES (20%): There will be approximately ten quizzes during the semester. Quizzes will be given toward the end of a class period and will be administered through Top Hat. Quizzes cannot be made up except under extenuating circumstances and with appropriate documentation. You will be allowed to use one sheet of notes (8.5 x 11 inches; both sides) and a scientific calculator on the quizzes.

IN-CLASS PARTICIPATION (20%): Throughout the semester I will pose questions during class using Top Hat. It is expected that you respond to these questions to the best of your ability. In the beginning these questions will be graded on participation only, but as we get used to using Top Hat, I will begin to grade your response to the questions, in part, on correctness.

Since participation is part of your grade, it is your responsibility to ensure that you have a suitable device for participating in class, and that your device is fully charged and available for use during every class period. However, I understand that sometimes issues arise, so if at any time you are unable to answer questions during class due to technical issues (e.g., phone or laptop battery died, broken device, etc.), please reach out to me as soon as the issue arises. And please note that the University does have laptops available for students to check-out for FREE in the event that your device is unavailable (see Resources below).

*The **Laboratory Section** will be conducted at a scheduled time outside of our class meeting, and it is worth 20% of your overall course grade. Your laboratory instructor will set the policies for lab, including grading. However, y*ou are required to earn a passing grade (≥60%) in your lab section to pass METR 100.*

FINAL PROJECT (20%): Rather than having a final exam in this course, your understanding of the material and your application skills will be assessed based on your ability to analyze a specific weather or climate event of the past, or to create a weather forecast, and describe/analyze that forecast. You will work together in groups of 4 – 6 students. Your grade will be determined by several factors, including: the accuracy of the content in your project (e.g., PowerPoint presentation to the class, movie, infographic, technical report, etc.), your contribution to the group project, and evaluations by your group members. More details regarding this project will be revealed later in the semester.

The final project which will bring together many of the tools you have learned about throughout the semester. Upon successful completion of this project, you will have demonstrated:

1. An understanding of basic atmospheric properties and processes.

2. The ability to:
    a. interpret weather and climate data,
    b. investigate questions they have about the data, and
    c. to make predictions using that data and determine uncertainties.

3. An appreciation for the complexity of the weather and the climate system, and to apply course concepts to their own observations of the natural world.

4. Specific transferable skills that are valued in any industry (i.e., marketing yourself to employers). Successful completion of this project will provide evidence of the following skills:

    - Teamwork
    - Written and/or verbal communication
    - Analytical skills
    - Technical skills
    - Organizational skills
    - Creative thinking

COMMUNICATION:

In person: If you have any questions or concerns, you can always drop by my office to see if I am available. During my office hours is the best time, but if that doesn't work for you just set up an appointment with me via MyPLAN, or email me.

By email: I regularly check my email (weekdays) and it is expected that you do the same.

Please communicate in a professional manner when sending emails. That means I expect you to write in full sentences and address/sign the email appropriately (e.g., Do not address me with "Hey" or forget to sign the email with your name). I will not reply to emails that must be decoded (i.e. acronyms or abbreviations typically used while texting). I will always confirm receipt of your email so if you do not receive a response from me, you can assume that I did not receive the email.

Academic Honesty: Any instance of academic dishonesty will be taken seriously, and substantial penalties will be levied. For UNL's student conduct code, see: (http://stuafs.unl.edu/ja/code/).

RESOURCES:

Reasonable Accommodation: The University strives to make all learning experiences as accessible as possible. If you anticipate or experience barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can discuss options privately. To establish reasonable accommodations, I may request that you register with Services for Students with Disabilities (SSD). If you are eligible for services and register with their office, make arrangements with me as soon as possible to discuss your accommodations so they can be implemented in a timely manner. SSD contact information: 232 Canfield Admin Bldg.; 402-472-3787 (see also http://www.unl.edu/ssd).

Equipment checkout: https://its.unl.edu/services/equipment-checkout

Computer Help Center: https://its.unl.edu/helpcenter

Resource centers:

Chemistry:	227 Hamilton Hall	https://chem.unl.edu/resource-center
Math:	13 Avery Hall	https://www.math.unl.edu/resources/undergraduate/mrc
Physics:	253 Jorgensen Hall	https://www.unl.edu/physics/resource-room
Writing:	102 Andrews Hall	https://www.unl.edu/writing/home

Study stops:

Love Library North	https://success.unl.edu/current/study-stop-schedule
Engineering	https://engineering.unl.edu/current-students/study-stop-city-campus/

It's my hope that we can have fun learning about weather and climate together, and that you will gain a greater appreciation for science in general. I also hope this course will build your critical thinking skills in a way applicable to other coursework, and to life in general. If you ever have questions about weather or climate, please ask!

**** Subject to change WITH notice ****

Schedule of Topics

DATE	Topics covered	Reading assignment	Assessment/Activity
	UNIT 1: Meteorological Basics		
1/8	**NO CLASS – Dr. K out of town**		
1/10	**NO CLASS – Dr. K out of town**	Chapter 1	
1/15	Introductions, Syllabus and Course Outline, Atmospheric composition, Atmospheric layers (by temperature)	Chapter 2 (and Chapter 1 if not already completed)	If our room were the atmosphere (demonstration)
1/17	Temperature, pressure, density		
1/22	**CLASSES CANCELED DUE TO WEATHER**	Chapter 3	
1/24	Station models, Surface pressure and temperature maps; Universal Coordinated Time	Chapter 4	
1/29	Rawinsondes and atmospheric soundings, Upper level maps	Chapter 5	**QUIZ #1** **Topics:** Temperature, pressure, density, station models
	UNIT 2: Energy		
1/31	Quiz #1 review Introduction to radiation; Energy transfer	Chapter 6	
2/5	Radar and satellite imagery	Chapter 7	**QUIZ #2** **Topics:** UTC conversions, surface and upper level weather maps
2/7	Quiz #2 Review Earth's energy balance Earth's seasons	Chapter 8	
	UNIT #3: Moisture		
2/12	Dewpoint temperature and relative humidity	Chapter 9	
2/14	Airmasses and fronts	Chapter 10	**QUIZ #3**

			Topics: Energy transfer, Earth's energy balance, Radar and satellite imagery
2/19	Quiz #3 Review Precipitation	Chapter 11	
2/21	Hurricanes	Chapter 12	**QUIZ #4** **Topics:** Dewpoint temperature, relative humidity, airmasses, fronts
	UNIT 4: Stability		
2/26	Quiz #4 review Assessing atmospheric stability	Chapter 12	
2/28	Assessing atmospheric stability (continued) **Introduce Final Project Details**	Chapter 13	**Final Project Instructions**
3/5	Thunderstorms	Chapter 14	**QUIZ #5** **Topics:** Precipitation, Hurricanes
3/7	Quiz #5 Review Radial velocity and mesocyclones, tornadoes	Chapter 15	
	UNIT 5: Forces of Motion		
3/12	Pressure gradient force (PGF), Coriolis force (CF) and geostrophic balance; hydrostatic balance **Final Project groups assigned**	**Schedule Final Project planning session with group** Chapter 16	
3/14	Jet stream, jet streaks	Review Chapters 15 and 16	**QUIZ #6** **Topics:** Stability, thunderstorms
3/19	**NO CLASS – SPRING BREAK**		
3/21	**NO CLASS – SPRING BREAK**		
3/26	Quiz #6 Review Friction and surface winds	Chapter 17	~~**QUIZ #7**~~ ~~**Topics:** PGF, CF, gravity, friction and geostrophic wind balance~~
3/28	Quiz #7 Review Life cycle of extratropical cyclones	Review Chapter 17	

4/2	Life cycle of extratropical cyclones (continued)	**Final project topic proposals DUE to Dr. Kopacz by 11:59pm** Chapter 18	
UNIT 6: Climate Extremes			
4/4	Difference between weather & climate		**QUIZ #8** **Topics:** Life cycle of extratropical cyclones, surface wind balance
4/9	Quiz #8 Review **Final project work day**	**Final project topic revisions DUE to Dr. Kopacz by 11:59pm** Chapter 19	
4/11	Drivers of climate change: past	Chapter 20	
4/16	Drivers of climate change: present & future	Chapter 21	
4/18	Climate extremes: Droughts & Floods		
4/23	POST-TEST for extra credit		**POST-TEST for extra credit**
4/25	**Final project work day**		
5/3*	**Final project presentations**	**Teach 105**	**10am – noon***

** This Schedule of Topics is subject to change *with* notice.**

Instructions for final project

There will be no final exam for this course. Instead we will spend the last few weeks of class working in groups on a final project that will be presented to the class during final exams week (see Important Dates for date/time). This project and presentation will account for 20% of your final course grade. The final project will be used to assess your understanding of the material and your application skills (ACE 4 outcomes). You will be required to analyze a weather or climate event, to prepare a technical summary describing the physical mechanisms responsible for that event, and to present your findings to the class.

You will work together in assigned groups of 5 – 7 students to analyze a weather or climate event. Your grade will be determined by several factors, including: participation during in-class work days, participation in a peer review process, a written report, the content of your group's presentation (PowerPoint, movie, etc.), your contribution to the group's oral presentation, and evaluations by your group members.

The general format of this project is as follows:

For this project you will investigate a particular topic related to atmospheric sciences (e.g., you might choose to investigate an interesting weather event of the past (e.g., tornado outbreak, blizzard, flooding event, etc.), or you could analyze a current weather event. While you will complete the data gathering and analysis as a group, each group member will be expected to compile a summary of the event (e.g., radar, satellite, etc.), and discuss the key meteorological features that contributed to the event (e.g., surface and upper level maps, soundings, etc.). This information will be compiled in a technical summary ***written in your own words***. As a group, you will also create a short presentation that summarizes your results for the class (see Technical summary and In-class presentation below).

Technical summary: You will prepare a formal write-up of your findings that is one to two pages in length (2 pages maximum, excluding figures and references). ***Each group member must turn in a technical summary written in their own words.*** Your write-up should include the following:

The main part of your paper (Introduction, Body and Summary) should be ***approximately*** 1 page, single-spaced (but ***no more than*** two pages). You must include ***at least*** two references for the information and images discussed in your technical summary. Your sources might include books (including your textbook), credible websites, etc. If you are unsure if a source is credible, please double check with me. All references must be properly cited in the references section and within your write-up and/or figure captions (see References below).

Your technical summary must also include all of the required sections as outlined on the following pages, each of which should be clearly labeled in bold within your paper. The final draft of your technical summary must be printed and turned in to Dr. Kopacz at the beginning of the final exam period. You must also save it as *lastname_finalproject_METR100_Spring2019* and upload it to Canvas under ***Final Project*** no later than the beginning of the final exam period. There are NO EXCEPTIONS to this deadline. Late papers will NOT be accepted.

It is expected that you have a clear understanding of writing basics, such as the use of proper grammar and spelling, correct sentence and paragraph construction, and effective overall paper organization. Your grade will largely depend on this. If you need additional assistance with these skills, you should visit the Writing Center in 102 Andrews Hall (https://www.unl.edu/writing/home). In addition to reviewing a draft of your paper, they also provide help with brainstorming and organization. This assistance is free of charge and available to all UNL students.

REQUIRED SECTIONS

Title: This should be short, concise, and an accurate statement of the contents of your paper.

Abstract: This is a succinct summary of your paper. It should clearly state the topic to be discussed and include a brief summary of important conclusions. TIP: Wait to write this until the rest of the sections are complete. Since it is a summary, it will be much easier to write after your paper is written.

Introduction: This section should contain general background information about the weather event you chose to analyze. You should explain what motivated you to investigate this particular weather event (e.g., Did you or a family member/friend experience the event?, Was it a memorable event in history?, etc.). You will briefly introduce the weather variables that will be discussed/analyzed in the Body and Results section of your paper (e.g., "In this paper we will analyze the Cattleman's Blizzard that occurred between October 3 -5, 2013. This was a notable event because…. In the sections that follow, we will examine surface weather conditions, upper level weather maps, and radar and satellite images to learn how this event developed and why this event was particularly devastating to the Black Hills region of the United States.").

Body and results: This will be the bulk of your paper. Here you will provide a detailed summary of the weather data related to your case study. Almost all of your figures will be presented/discussed in this section (although the figures themselves should appear in the Figures and Captions section below). Some questions to consider for this portion of the paper are:

What weather variables will be important to understanding how this particular event unfolded?

What were surface weather conditions before, during and after the event?

What were upper level weather conditions before, during and after the event?

Would radar or satellite imagery be useful for your analysis?

Summary: This section summarizes your body and results section and is where you will address the question laid out in your introduction and answered in your body/results (e.g., What weather factors lead to the devastating Cattleman's Blizzard in the Black Hills region of the United States?).

References: You must list your references (at least two) according to the AMS (American Meteorological Society) guidelines as outlined in the AMS Journal Authors Guide: (https://www.ametsoc.org/ams/index.cfm/publications/authors/journal-and-bams-authors/formatting-and-manuscript-components/references/). All references must be properly cited within the text according to AMS formatting.

Figures and figure captions: You must include *at least* 3 figures which helps to clarify your discussion. All images require a figure number and figure caption, and when applicable, a colorbar/scale. Whether you are using current or archived images from a website, or real-time images, you must include the source of your figure in your reference list.

You must interpret each chart/figure used WITHIN the body of your technical summary, and explain how it contributes to our understanding of the event (e.g., Figure 1 is a base reflectivity radar image. It can be used to help determine which areas were receiving snow during the blizzard event. From this radar image we can see that….).

The figure caption should be brief. Captions do not require full sentences, rather they concisely describe the contents of the figure. The figure(s) must be numbered clearly. That is, if you have more than one figure, they must listed in the order in which they are discussed. All figures must be properly cited (i.e., "from NOAA (2009)" or "adapted from NWS (2009); their Figure 2). For example, the caption for the first figure discussed might be written as: "Figure 1: Radar base reflectivity image from October 4th, 2013 at 18Z (NWS (2013))". The figure itself will be included with a caption at the end of your document.

Your technical summary will be reviewed using the rubric shown on the last page of this document.

In-class presentation: Your group must create an oral presentation that will allow you to present your results to the class. You can use any format you wish (video, PowerPoint, demonstration, etc.), but it is expected that you will describe the significance of your chosen topic, share and describe at least three images, and summarize your group's findings. Each group member should plan to spend approximately 1 minute presenting the findings. Your group's presentation should be approximately 5 minutes but no longer than 7 minutes.

Expectations for group work: All communications among groups MUST take place on Canvas. You are adults, so it is expected that you will work together to distribute the workload fairly and speak up when you feel that a team member is not pulling their weight. Be respectful, but be assertive. You should not expect your group members to do all the work for you, nor should you be expected to complete a larger portion of the work than the rest of your group. Should a scenario arise where you are unable to motivate a person to contribute to the group, then please inform me privately via email or by dropping by my office. I will do the best to remedy the situation in a positive way. If it is determined that you as a group member are not pulling your weight, this may result in a reduction of your final project score, or may result in you being removed from your group.

Grading of the final project: The grade for the final project will come from several items/activities:

Final project topic proposals:	5 points
Final project work day #1:	10 points
Final project work day #2:	10 points
Final project presentation:	25 points
Final project technical summary:	50 points
TOTAL:	100 points

Your total score on the final project will be factored into your overall course grade and will account for 20% of your final course grade.

Important dates:

March 12th: Schedule final project planning session with group members. This session should be used to brainstorm, find data/information, and to come up with a project plan. I will create a group in Canvas for you to collaborate (How do I view my Canvas groups? https://guides.instructure.com/m/4212/l/55565-how-do-i-view-my-canvas-groups-as-a-student). This will allow you to email each other and even hold an online discussion forum with your group members.

April 2nd: Submit final project topic proposal (ONE per group) to Dr. Kopacz via Canvas (5% of final project grade). This item should be saved as *Group#_finalproject_topicproposal* and uploaded to Canvas under *Final Project Topic Proposal* no later than 11:59pm.

April 9th: Your final project topic proposal will be reviewed and graded for clarity, organization, etc. Anything lower than a perfect score (5 points or 100%) can *and should* be revised and re-submitted (ONE revision per group). This item should be saved as *Group#_finalproject_topicproposal_revisions and will be uploaded to Canvas under Final Project Topic Proposal* no later than 11:59pm.

April 9th: Final project work day (in class; attendance required, 10% of final project grade). The entire class period will be used for groups to meet, gather and analyze data, create and plan oral presentations, and consult with Dr. Kopacz.

April 25th: Final project work day (in class; attendance required; 10% of final project grade). The entire class period will be used for groups to meet, gather and analyze data, create and plan oral presentations, and consult with Dr. Kopacz.

Friday, May 3rd, 2019 (10am – noon) in Teachers College Hall Room 105:

Final project oral presentations: These will be given in class (25% of final project grade). All items that you plan to use during your group's oral presentation must be saved as *Group#_finalproject_oralpresentation* and uploaded to Canvas under *Final Project Oral Presentation*. This should be submitted before the beginning of the final exam period.

Final project technical summary: You will submit your technical summary in-person and online (50% of final project grade). The final draft of your technical summary must be printed and turned in to Dr. Kopacz at the beginning of the final exam period. You must also save it as *lastname_finalproject__technicalsummary* and upload it to Canvas under *Final Project* no later than the beginning of the final exam period.

Please note: In addition to your group's presentation, you are expected to be present for ALL of the presentations made in class that day. *You will not receive credit for your presentation if you are not present for the other group's presentations.*

Potential sources for data include, but are by no means limited to:

a. **National Hurricane Center Data Archive**: https://www.nhc.noaa.gov/data/?
b. **NOAA's Storm Prediction Center Archive:** https://www.spc.noaa.gov/archive/
c. **UCAR Image Archive:** http://www2.mmm.ucar.edu/imagearchive/
d. **NOAA's National Center for Environmental Information:** https://www.ncdc.noaa.gov/stormevents/
e. **Storm Prediction Center's Severe Weather Event archive:** https://www.spc.noaa.gov/exper/archive/event.php
f. **Compilation of links to archived weather data:** http://schumacher.atmos.colostate.edu/resources/archivewx.php

g. **Lincoln, NE Weather and climate data:** https://lincolnweather.unl.edu/
h. **Storm Prediction Center's current surface maps:** https://www.spc.noaa.gov/exper/surfaceMaps/
i. **National Weather Service current maps and data:** https://www.weather.gov/

Have fun with this! Pick a topic that interests you so it won't seem so much like work. Well, as much fun as you can have while doing an assignment.

Potential Topics

Heat waves/ Droughts/Floods

Blizzards, freezing precipitation and ice storms

Thunderstorms/Tornadoes

Extratropical cyclones (weather "bombs")

Hurricane

Nor'Easter

Climate Change

UNL's ACE 4 Rubric (TO BE USED FOR REVIEW OF TECHNICAL SUMMARY):

ACE 4 Use scientific methods and knowledge to pose questions, frame hypotheses, interpret data, and evaluate whether conclusions about the natural and physical world are reasonable.

	Exemplary 4	Acceptable 3	Developing 2	Deficient 1
Use Scientific Knowledge	Demonstrate knowledge of appropriate background information from texts and incorporates relevant information from primary literature.	Demonstrates knowledge of appropriate background information from texts.	Demonstrates familiarity with background knowledge, but with gaps that limit ability to ask appropriate questions.	Lacks the background knowledge and context to ask appropriate questions.
Pose Questions	Poses questions that can be investigated and that are within the context of existing knowledge. In addition these questions are differentiated into hierarchical levels.	Poses questions that can be investigated and that are in the context of existing knowledge.	Poses questions that can be investigated, but lack connections to existing knowledge.	Cannot frame appropriate questions that can be investigated using scientific methods.
Frame Hypotheses	States a clear and relevant hypothesis logically related to existing knowledge, clearly describes alternative hypotheses, and identifies experimental predictions.	States a clear and relevant hypothesis that is logically related to existing knowledge but does not describe alternative hypotheses and does not make experimental predictions.	A relevant hypothesis is stated, but it is not logically related to existing knowledge.	Hypothesis does not logically address the stated question.
Interpret Data	Interprets data utilizing quantitative analysis, and forms data into tables or figures with interpretation appropriate to the question.	Forms data into tables or figures with interpretation appropriate to the question but does not conduct any quantitative analysis of data.	Forms data into tables or figures but without interpretation of these.	Does not interpret data when it is provided in a table or figure.
Evaluate Whether Conclusions are Reasonable	Relates results to the initial question and to background knowledge; broadens results to an appropriate scope of inference, including an estimate of error or uncertainty.	Relates results appropriately to the initial question and to background knowledge but does not describe the scope of inference for results and does not estimate uncertainty.	Relates results to the initial question but does not also relate these to background knowledge.	Does not reach conclusions that relate to the main question.

https://ace.unl.edu/ACE%204%20Rubric%20Revised%204-27-16.pdf

ADDITIONAL items that I will be looking for in your technical summary other than content/skills in ACE 4 rubric above.

	4 - Exemplary	3	2	1 - Deficient
Uses correct grammar, syntax, punctuation, and spelling.	4 Paper is entirely error-free and reads smoothly.	3 Paper has typos and some errors, but the errors do not detract from the reader's comprehension of the text or distract overly much.	2 Sentences are well-structured, but paper contains punctuation, grammar, and spelling errors that seriously distract a reader.	1 Sentences are not well-structured; paper contains several sentence fragments, mixed constructions, and other errors that make it difficult to understand.
Scientific terminology, equations, and notation are appropriate and correctly used.	4 Correct terminology and notation are always used demonstrating a complete understanding of concepts.	3 Correct terminology and terms are usually used. Equations clarify discussion and all variables are defined.	2 A few scientific terms, equations, and notation are used and are sometimes appropriate.	1 There is little use, or a lot of inappropriate use, of terminology, equations, and notation.
Figures add to clarity of paper and are properly explained and cited	4 Figures were easy to read and fully supported research findings; captions were descriptive and proper citations were used.	3 Figures and their captions were generally clear and supportive of discussion.	2 Figures were generally supportive of research findings, but their descriptions and/or citations were unclear/incomplete	1 Few or no figures were used, and/or the figures were not supportive of research findings

RUBRIC for ORAL PRESENTATION:

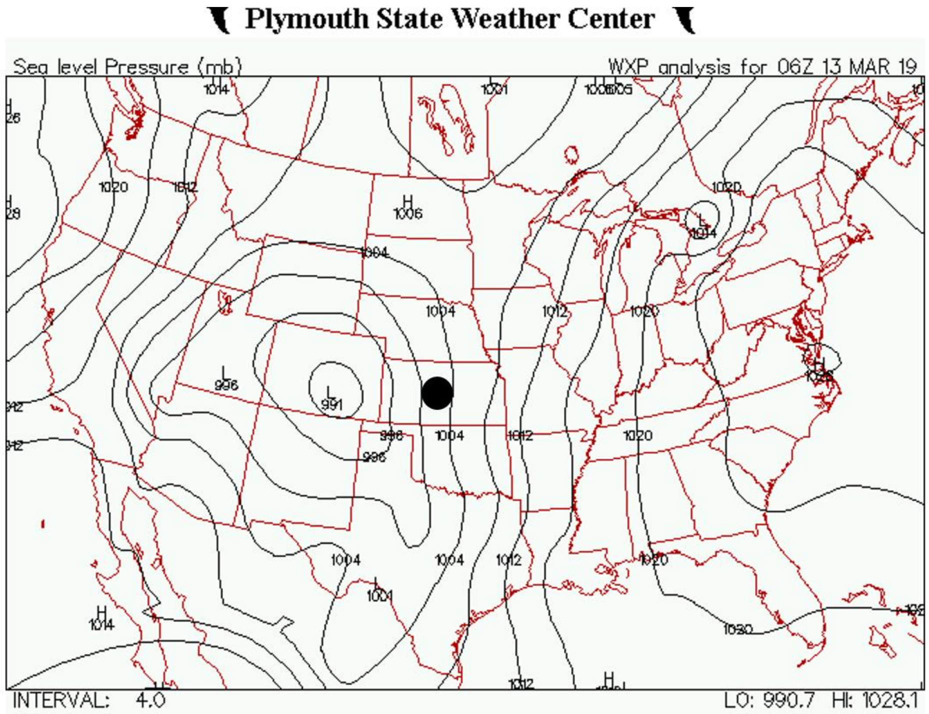
	4 - Exemplary	3	2	1 - Deficient
Demonstrates capacity to develop a central message	Central message is compelling (precisely stated, appropriately repeated, memorable, and strongly supported.)	Central message is clear and consistent with the supporting material.	Central message is basically understandable but is not repeated and is not memorable.	Central message can be deduced, but is not explicitly stated in the presentation.
Demonstrates capacity to effectively organize the oral message	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is clearly and consistently observable and is skillful and makes the content of the presentation cohesive.	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is clearly and consistently observable within the presentation.	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is intermittently observable within the presentation.	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is not observable within the presentation.
Demonstrates the capacity to identify and incorporate supporting material	A variety of types of supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make appropriate reference to information or analysis that significantly supports the presentation.	Supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make appropriate reference to information or analysis that generally supports the presentation.	Supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make appropriate reference to information or analysis that partially supports the presentation.	Insufficient supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make reference to information or analysis that minimally supports the presentation.

APPENDIX B – SAMPLE IN-CLASS ACTIVITY

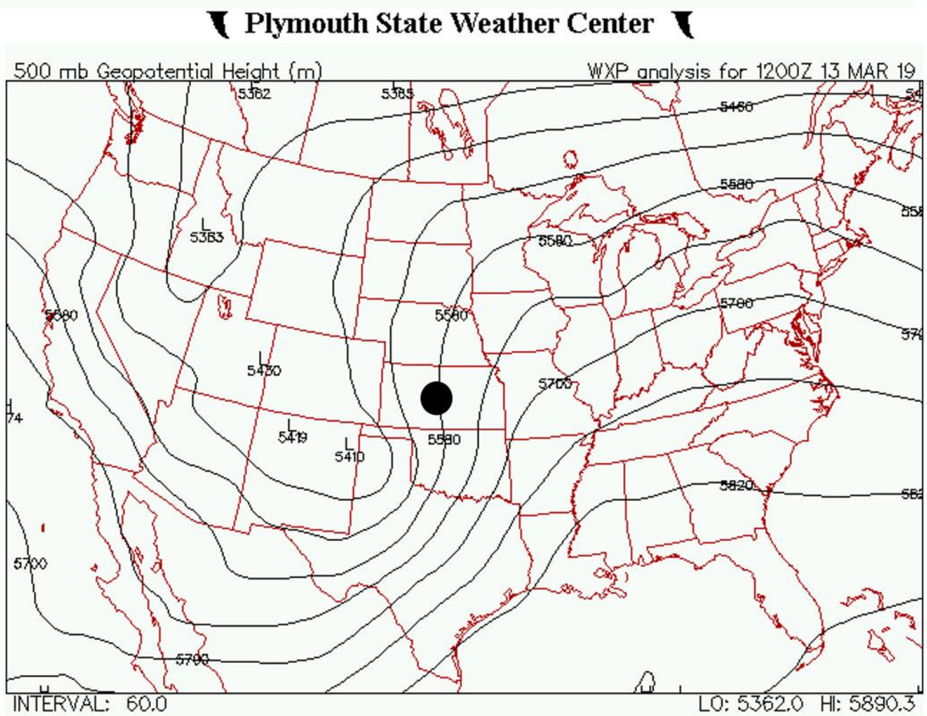
(Addresses Course Learning Goals 1 and 2 a-c)

By how much does the pressure vary across Kansas (from west to east)

At the black dot, draw a wind barb to represent wind direction (FROM which it is coming)



At the black dot, draw a wind barb to represent wind direction (FROM which it is coming)



By how much does the pressure vary across Kansas (from west to east)

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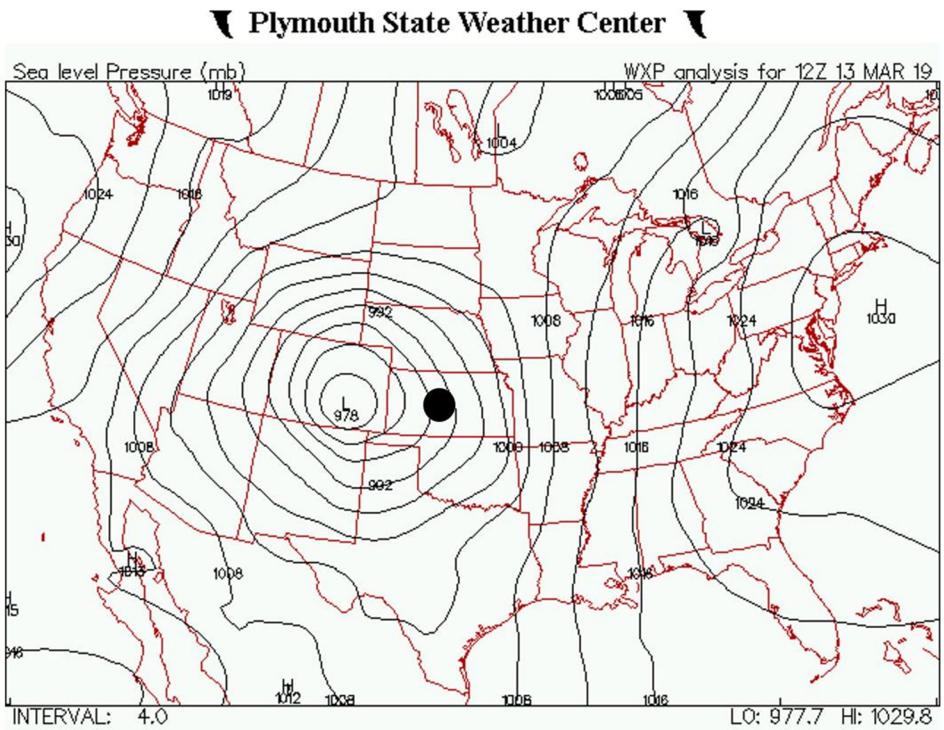
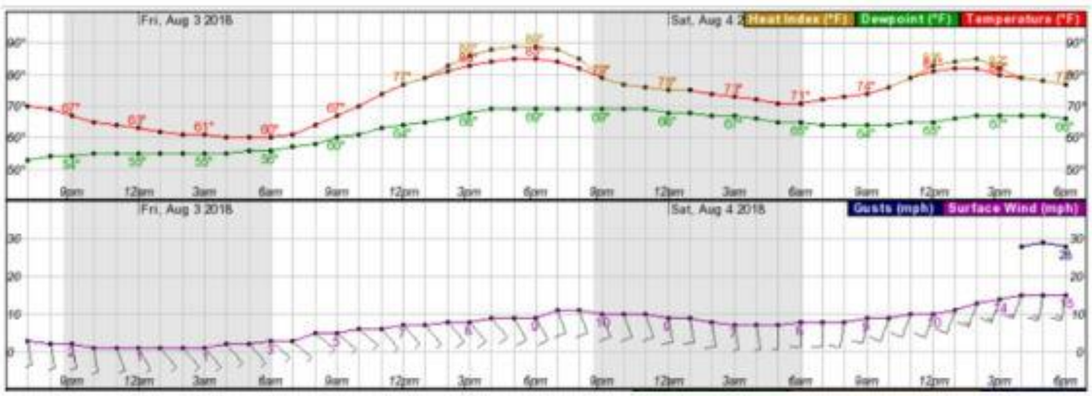


APPENDIX C – SAMPLE PRE-POST-TEST QUESTIONS

Interpret Data

Q1.

As a forecaster, you look at the hourly forecast information for the next 24 hours:



Given the temperature, dew point and wind speed/direction information provided above, which of the following below do you conclude?

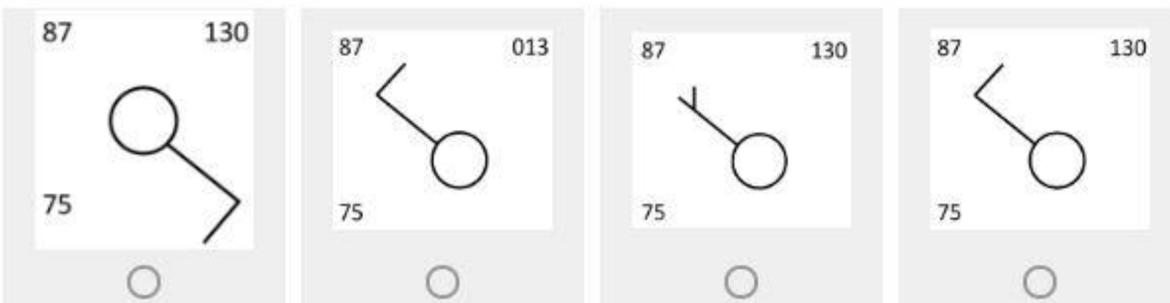
- ○ A warm front is expected to pass through the region.
- ○ A cold front is expected to pass through the region.
- ○ A dry line is expected to pass through the region.
- ○ A stationary front is expected to pass through the region.

Q2.

The following weather observations were made in New York, New York:

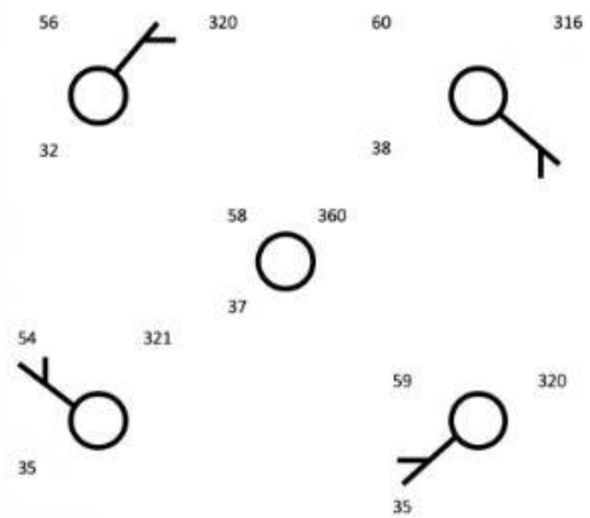
The surface temperature is 87°F with a dew point temperature of 75°F. The wind is from the northwest at 10 knots. The sea level pressure is 1013.0 mb. The skies are clear at this time.

Which of the four surface weather station models below most accurately represents the conditions in New York, NY?



Q12.

Consider the figure below, which shows a series of surface weather stations within a region.



What type of feature listed below is likely impacting all stations shown in this figure?

- ○ Northern Hemisphere low-pressure system
- ○ Northern Hemisphere high-pressure system
- ○ Southern Hemisphere low-pressure system
- ○ Southern Hemisphere high-pressure system

Use Scientific Knowledge

Q4.

In which layer of the atmosphere does air temperature decrease with increasing altitude?

- ○ Troposphere
- ○ Stratosphere
- ○ Tropopause
- ○ Thermosphere

Evaluate Conclusions

Q10. Suppose you are taking a trip to northern Wisconsin in early December to get some last-minute fishing in at a friend's cabin by an inland lake before the lake freezes over during the winter. You check the forecast and learn that light winds will be moving a continental Arctic air mass into the region (with below freezing temperatures), leading to substantially colder than average temperatures while you will be there. However, the relative humidity on the morning you are fishing is supposed to be 100%. Your friend states that you should expect to observe radiation fog when you arrive.

Which of the following would be the correct response to your friend?

- ○ "Yes, I also expect to observe radiation fog!"
- ○ "No, but we will be observing advection fog."
- ○ "No, but we will be observing steam fog."
- ○ "No, but we will be observing valley fog."